# Waterford Flat Quadrangle, Maine


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Funding for the preparation of this map was provided in part by the U.S. Geological Survey STATEMAP Program, Cooperative Agreement No. 99HQAG0119.



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**Open-File No. 00-133**
**2000**

For additional information, see Open-File Report 00-136


## SURFICIAL GEOLOGY OF MAINE

Continental glaciers similar to the ice sheets in Greenland and Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 2 million and 10,000 years ago. The sediments that cover much of Maine are largely the product of glaciation. Some of these sediments were released directly from the ice, forming deposits of till (**Figure 1**); others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the distribution of glacial sediments in the Waterford Flat quadrangle.

The most recent "Ice Age" in Maine began about 25,000 years ago, when an ice sheet originating in Canada spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier caused the land to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed (**Figure 2**). The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock and they are important indicators of the direction of ice movement. Glacial erosion and sediment deposition combined to give a streamlined shape to many hills, with their long dimension parallel to ice flow. These and other hills may be more-or-less covered by compact glacial sediment (lodgement till) plastered under great pressure beneath the ice. The south sides of many hills are steeper and have exposed bedrock due to glacial plucking (**Figure 3**).

A warming climate forced the ice sheet to start receding as early as 21,000 years ago, soon after it reached its southernmost position on Long Island (Sirkin, 1986). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by 14,000 years ago (Kaplan, 1994; Dorion, 1997). Even though the weight of the ice was removed, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated northward. Ocean waters extended far up the Androscoggin, Kennebec, and Penobscot valleys, reaching present elevations up to 420 feet in the central part of the state. Ridges of till and/or sand and gravel (end moraines) were formed along successive positions of the retreating ice margin.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the ice disappeared. Maine's esker systems can be traced for up to 100 miles and are among the longest in the country. Sand and gravel accumulated as deltas and submarine fans where the glacier terminated in the sea, while the finer silt and clay dispersed across the ocean floor. Shells of clams, mussels, and other invertebrates are found in the glacial-marine clay (Presumpscot Formation) that blankets the lowlands of southern Maine. Ages of these fossils determined from radiocarbon dating tell us that ocean waters covered parts of Maine until about 11,000 years ago, when rebound of the land surface brought the coastal zone above sea level.

Above and inland from the zone of marine submergence, meltwater flowing off the ice margin carved channels on hillsides. Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier (**Figure 4**). In some places deltas were built into temporary lakes that were dammed by glacial ice or short-lived sediment barriers (**Figure 5**). Many of these water-laid deposits are well layered and sorted, in contrast to the chaotic mixture of clay, silt, sand, and rocks (till) released from dirty ice without reworking by water. Boulders commonly are scattered across the landscape in till-covered areas. End-moraine ridges were constructed along the ice margin where the glacier was still actively flowing and conveying rock debris to its terminus, but moraines are not as common in the interior of Maine as in the coastal lowland.

The last remnants of glacial ice probably were gone from Maine by 10,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land, and worldwide sea level is gradually rising against Maine's coast.

### References Cited


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**Figure 1:** View northwest along pipeline trench cutting hummocky till deposits between Baker Hill and Crooked River in Waterford.

**Figure 2:** Ledge exposed in floor of former borrow pit, south face of Deer Hill in Waterford. Striations on this bedrock surface indicate glacial flow toward the southeast and south-southeast.

**Figure 3:** Cliff resulting from glacial plucking on south face of Hawk Mountain in Waterford.

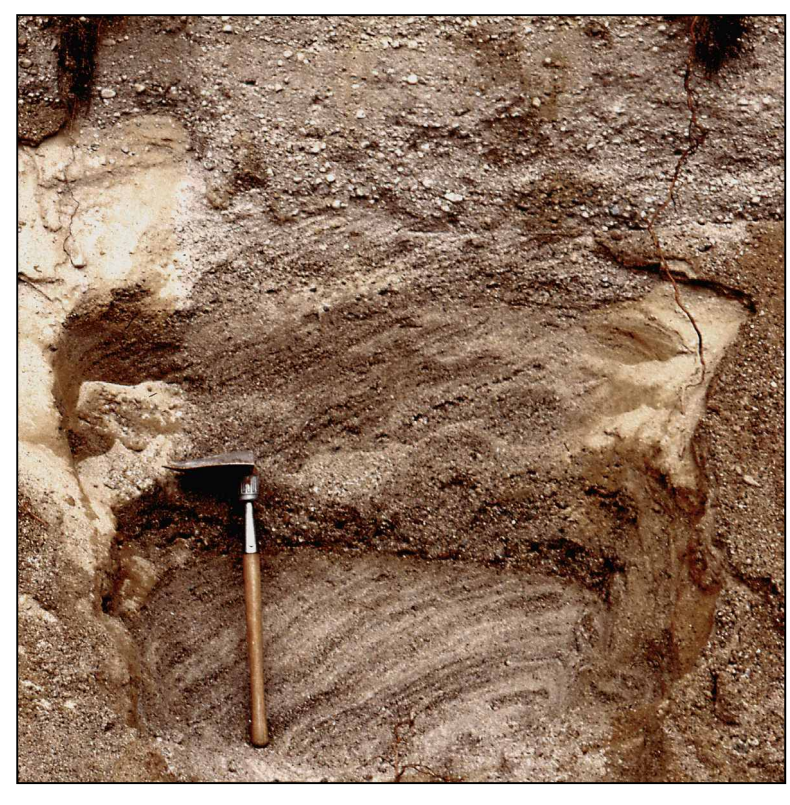

**Figure 4:** Cross-bedded glacial outwash in Crooked River valley, East Waterford.

**Figure 5:** Sand beds of possible deltaic origin, east side of Crooked River valley in Norway.

**Figure 6:** Borrow pit southeast of Rice Hill in Waterford, showing till overlying glacial sand and gravel.

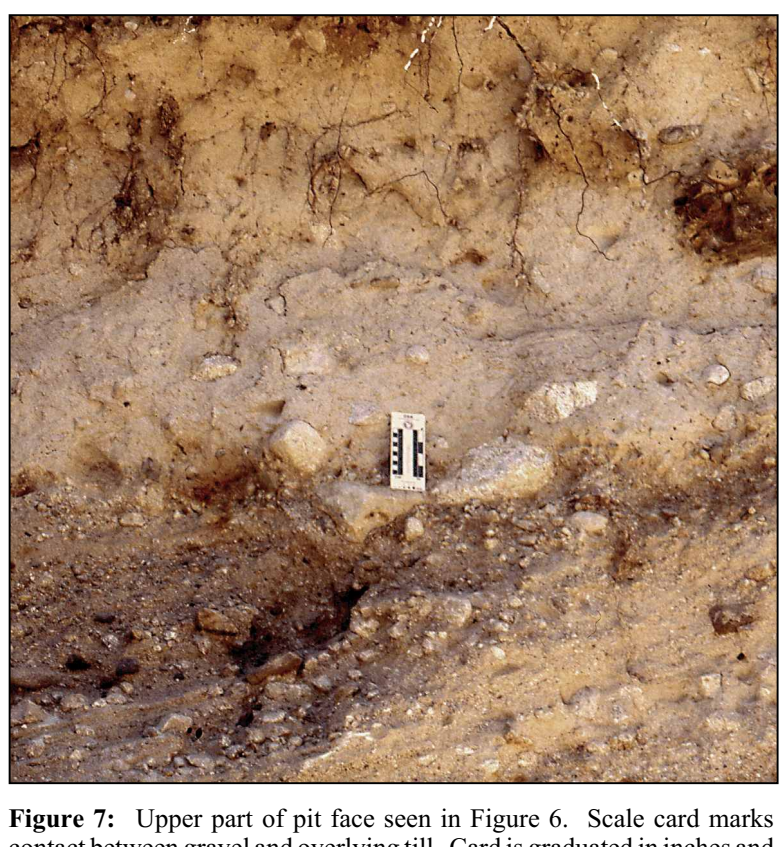

**Figure 7:** Upper part of pit face seen in Figure 6. Scale card marks contact between gravel and overlying till. Card is graduated in inches and centimeters.

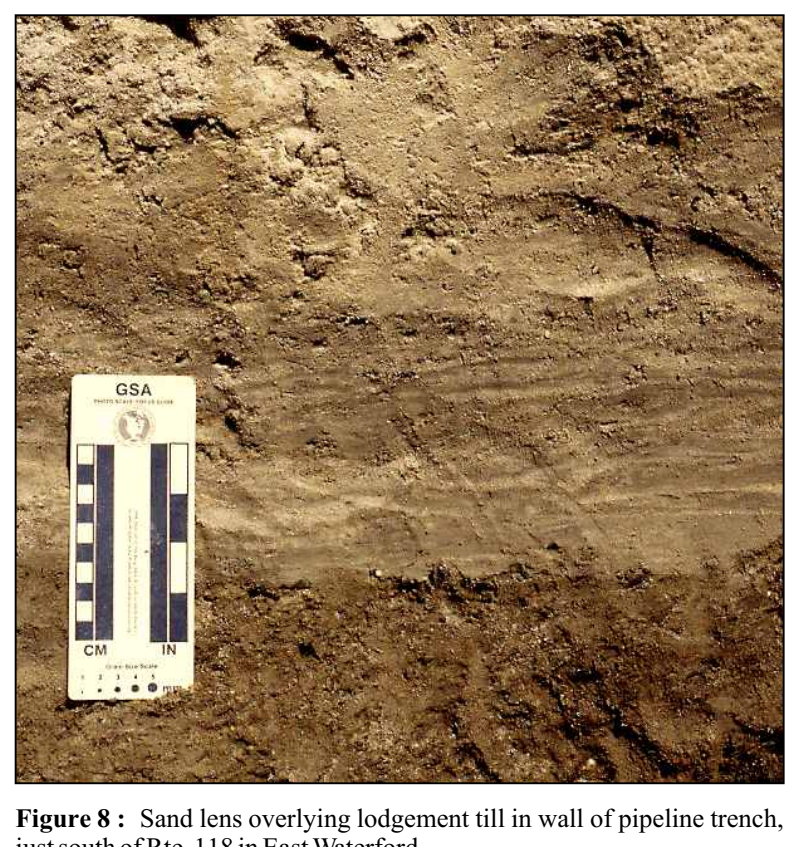


**Figure 8 :** Sand lens overlying lodgement till in wall of pipeline trench, just south of Rte. 118 in East Waterford.